PART 1 – GENERAL

1.01  SECTION INCLUDES

A. Existing system description
B. Modification and additional requirements
C. System interface requirements
D. Radio systems location
E. Dispatcher console equipment
F. Installation, optimization, and field testing
G. Training and support

1.02  RELATED SECTIONS

A. Section 01 33 00, Submittal Procedures
B. Section 01 33 23, Shop Drawings, Product Data and Samples
C. Section 33 83 02, Radio Network/Monopole Antenna Tower
D. Section 33 83 03, Radio Network/Antenna System
E. Section 33 83 04, Radio Network/Distributed Fiber/Amplifier RF Radiating Cable System
F. Section 33 83 05, Radio Network/Regional High-Level Radio System
G. Section 33 83 06, Radio Network/Fiber Distributed Antenna Systems/Bi-Directional Radio Amplifier Systems
H. Section 33 83 07, Radio Network/Mutual Aid Radio System

1.03  MEASUREMENT AND PAYMENT

Separate measurement and payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work of this Contract.
1.04 REFERENCES

A. Federal Communications Commission (FCC) Rules:
   1. CFR Title 47 CFR, Telecommunications

B. MACOM Incorporated:
   1. Document AE/LZT 123 4618/1, Site Grounding and Lightning Protection

C. National Public Safety Planning Administration Committee (NPSPAC) Region 6 (Northern California) planning regulations for 800 MHz Public Safety Agencies

D. Telecommunications Industry Association (TIA):
   1. Technical Systems Bulletin, TSB 88-.1, .2, .3, .4, .5

E. US Department of Homeland Security (DHS):
   1. Project 25 Compliance Assessment Program (P25 CAP)
   2. Project 25 (P25 or APCO-25) – standard for digital radio communications

1.05 BART TRUNKED RADIO SYSTEM DESCRIPTION

A. The District owns and operates an 800 MHz radio network. Modifications to the radio network are anticipated over time due to upgrade and expansion of the BART system. It is planned to fully upgrade the BART radio to a P25 Phase 2 System by year 2025, through phased steps with full integration and operation between new and old systems. One element of the BART radio communications network is the trunked radio system, which facilitates communications above and below ground. The trunked radio system is used for voice communications between the Operations Control Center (OCC) and trains, BART police dispatch and police officers, coordination of maintenance workers, and administrative purposes. The system is used for both communications above and below ground. It is the primary real-time communication method for train control and for BART Staff throughout the District.

B. Radio base stations are located at the following sites:

   1. BART base stations - 10 trunk channels
      a. (e) Millbrae - EDACS
      b. (e) Colma - EDACS
      c. (e) Bernal Heights - EDACS
      d. (e) Lake Merritt - EDACS
      e. (e) El Cerrito Del Norte - EDACS
      f. (e) Walnut Creek West - EDACS
g. (e) Willow Pass - EDACS
h. (e) Schaeffer Ranch - EDACS
i. (e) East Dublin - EDACS
j. (e) Bay Fair - EDACS
k. (e) Union City - EDACS
l. (e) Warm Springs - EDACS

2. BART High Sites - 2 single conventional channels
   a. Twin Peaks (SF)
   b. Vollmer Peak (Caldecott)
   c. Cummings Skyway (Crockett)
   d. Highland Peak (Dublin Grade)

3. Future sites or alternative coverage will be required for future extensions:
   a. SVBX San Jose Airport – Base Stations at Santa Clara and Alum Rock/Berryessa
   b. Livermore
   c. Brentwood

The existing above ground Trunked Radio System is a 10 channel Enhanced Digital Access Communications System (EDACS™) simulcast system, as manufactured by MACOM/Ericsson/Harris Corp. It operates at 800 MHz, on National Public Safety Planning, Advisory Committee (NPSPAC) frequencies. New expansion and upgrade to a P25 Phase 2 System will use the same base channels for its trunked system, while expanding capacity to 18 operational voice channels with its time-slot architecture. Current BART simulcast channels are shown in Table 1.

<table>
<thead>
<tr>
<th>EDACS</th>
<th>BART</th>
<th>Trunked</th>
<th>12.5 kHz</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MHz</td>
<td>MHz</td>
<td>NPSPAC</td>
</tr>
<tr>
<td>Channel</td>
<td>Tx</td>
<td>Rx</td>
<td>Channel</td>
</tr>
<tr>
<td>1</td>
<td>851.0375</td>
<td>806.0375</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>851.3125</td>
<td>806.3125</td>
<td>24</td>
</tr>
<tr>
<td>3</td>
<td>851.5625</td>
<td>806.5625</td>
<td>42</td>
</tr>
<tr>
<td>4</td>
<td>851.8875</td>
<td>806.8875</td>
<td>68</td>
</tr>
<tr>
<td>5</td>
<td>852.0375</td>
<td>807.0375</td>
<td>78</td>
</tr>
<tr>
<td>6</td>
<td>852.2375</td>
<td>807.2375</td>
<td>94</td>
</tr>
<tr>
<td>7</td>
<td>852.5625</td>
<td>807.5625</td>
<td>118</td>
</tr>
<tr>
<td>8</td>
<td>852.8125</td>
<td>807.8125</td>
<td>138</td>
</tr>
<tr>
<td>9</td>
<td>853.0375</td>
<td>808.0375</td>
<td>154</td>
</tr>
<tr>
<td>10</td>
<td>853.3625</td>
<td>808.3625</td>
<td>180</td>
</tr>
</tbody>
</table>

Table 1: Current BART Simulcast Channels
Additionally, there is a Harris Corp P25 Core and 6 channel Trunked Radio System for underground only use. Currently, this is only used for inter-agency interoperability, first responders and integration of new radio consoles above and beyond the capacity of the current EDACS System. The current BART simulcast “underground only” channels are shown in Table 2.

Table 2: Current BART Simulcast Underground Only Channels

<table>
<thead>
<tr>
<th>P25</th>
<th>BART MHz</th>
<th>Trunked MHz</th>
<th>12.5 kHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>BART Channel</td>
<td>Tx</td>
<td>Rx</td>
<td>NPSPAC Channel</td>
</tr>
<tr>
<td>1</td>
<td>851.6375</td>
<td>806.6375</td>
<td>48</td>
</tr>
<tr>
<td>2</td>
<td>852.1625</td>
<td>807.1625</td>
<td>88</td>
</tr>
<tr>
<td>3</td>
<td>852.3375</td>
<td>807.3375</td>
<td>102</td>
</tr>
<tr>
<td>4</td>
<td>852.6500</td>
<td>807.6500</td>
<td>125</td>
</tr>
<tr>
<td>5</td>
<td>853.6750</td>
<td>808.6750</td>
<td>205</td>
</tr>
<tr>
<td>6</td>
<td>853.8625</td>
<td>808.8625</td>
<td>220</td>
</tr>
</tbody>
</table>

Other conventional channels are also in-use. Current BART conventional BART High Sites and underground channels are shown in Table 3.

Table 3: Current BART Conventional High Site and Underground Channels

<table>
<thead>
<tr>
<th>BART Conventional</th>
<th>Duplex Systems</th>
<th>12.5 kHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel ID</td>
<td>Used By MHz</td>
<td>Base Tx Rx MHz</td>
</tr>
<tr>
<td>BART HL 2</td>
<td>BART PD</td>
<td>851.1000</td>
</tr>
<tr>
<td>CA HL FIRE 1</td>
<td>Mut Aid</td>
<td>853.9875</td>
</tr>
<tr>
<td>CA LL LAW 9</td>
<td>Mut Aid</td>
<td>851.2000</td>
</tr>
<tr>
<td>BART HL 1</td>
<td>BART</td>
<td>853.5375</td>
</tr>
</tbody>
</table>

C. The radio system is designed to provide clear, intelligible communication from portable radios with area coverage reliability of 95 percent or better. In some locations, radio signal penetration into wayside facilities is insufficient to provide this level of communication performance. The provision of Fiber Distributed Antenna Systems (Fiber DAS) or Bi-Directional Radio Amplifier (BDA) systems, with redundant delivery and adjacent UPS services within such facilities corrects for this condition.

D. In underground areas of the BART system, the trunked radio signals are propagated by a Commscope (formerly Andrews) Fiber DAS adjacent to each track on opposite tunnel sides. Independent base station radio feeds are used for each redundant Fiber DAS head-end node. These then send radio signals over fiber to redundant transmission nodes (Remote Units - RU) in each typically 2000 feet long RF segment; the RF segments use two Radiax (Coaxial Radiating Cable) cables for passive delivery, one for below ground radio transmission (downlink) and the other for reception (uplink). Each Fiber DAS node shall have its own 48 VDC UPS power capable of sustaining radio service greater than eight hours. Optical Fiber DAS with redundant delivery feeds from two ends of tunnel.
1.06 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures, and Contract Specifications Section 01 33 23, Shop Drawings, Product Data and Samples, for submittal requirements and procedures.

B. Shop Drawings: Submit Shop Drawings including but not limited to the following:

1. Logical network diagrams.
2. Radio Frequency (RF) predictive coverage design maps.
3. Systems Block diagrams showing major gain or loss elements, all downlink single and combined and uplink power levels.
5. Power Budget Diagrams.
6. Panel and cabinet layouts.
7. UPS protection systems.
8. Equipment interconnection diagrams.
9. Equipment and material lists.
10. Manufacturer’s descriptive and technical literature.
11. Equipment specification sheets and installation instructions.
12. If requested by the Engineer, a design review meeting shall be held in a District facility for the Contractor to present the required design submittal(s).
13. Design, validation, and test planning shall be submitted for equipment Factory Acceptance Testing (FAT), equipment installation, turn-on, configuration, testing and commissioning, failover, workmanship for RF transmission components and systems, RF systems sweep tests, RF PIM tests, optical Fiber DAS systems OTDR, RF signal strength coverage mapping, uplink power strength throughout coverage area, radio testing, voice quality, BER, DBER for all radio types, multiple unit testing, RF feed redundancy test, and diverse geographic testing.

C. Design validation, workmanship validation of components and systems, completion of test plans, coverage validation, core and application functionality, quality of radio service in all locations shall be completed before system is certified operational and commissioned.
PART 2 – PRODUCTS

2.01 DESIGN

A. General

1. The Trunked Radio System shall provide trunked radio coverage inside and around areas along the BART track alignment, at BART premises, offices, parking lots, above ground, below ground, inside tunnels, stations, subways, and trenches. At least 95 percent area coverage shall be provided inside the wayside facilities including that required for operational and mandated emergency services in passenger stations, parking garages, train control and communications room, traction power substations, maintenance yard and shops, revenue processing buildings, administration buildings, revenue vehicles, Park and Ride locations, and other BART facilities supporting train operations, maintenance, administration, engineering, and police activities. Above ground coverage shall extend 1.5 miles in both directions of the rail alignment at the prescribed performance levels. 95 percent coverage shall be considered for all individual work areas, rooms, structures and the whole RF coverage area.

2. The system reliability performance goals of the trunked system shall be with 95 percent coverage at 99 percent of the time. The system shall be balanced between talk out and talk in directions; mobile radios shall be set for 5-watt output and portables shall be set for 3-watt output. Coverage shall deliver performance deemed “loud and clear with occasional background noise”, and as defined in TIA Standard TSB 88-.1, .2, .3, .4, .5, Delivered Audio Quality (DAQ) shall be at 4.0 or above. The system reliability performance shall analyze the space inside of BART revenue vehicle (with closed doors) throughout the district trackway as a separately evaluated coverage area. Performance standards shall be based upon use of handheld portable radios and small antennas carried at the hip on the belt.

3. In underground trackway, stations, and facilities, a connection to the redundant units and UPS powered Commscope (formerly Andrews) Fiber DAS shall be deployed to extend the above ground trunked radio signals into the underground. The requirements for the distributed underground amplifier network are detailed in Contract Specifications Section 33 83 06, Radio/Bidirectional Radio Amplifier System and Section 33 83 04, Radio Network/Distributed Amplifier Radiating Cable System.

4. Trunked radio core and base station system equipment shall be designed to operate in an environmentally controlled facility, with continuous UPS power systems.

5. Trunked radio system equipment shall be housed in cabinets meeting current California Building Code Seismic Requirements, and cabinets shall be secured by current California Building Code seismic design stamped by a qualified California Licensed Engineer.
6. Trunked Radio System site equipment shall be powered by utility power with an automatic start generator-standby source, connected to the trunked system via an automatic transfer switch (ATS). Battery UPS shall be provided either as part of the generator, UPS, mains, ATS or within the equipment racks providing eight hours of back up, though trunked capacity can be temporarily downsized. The generator shall be sized to handle design operating loads for the radio equipment and supporting environmental equipment, with 30 percent spare capacity. The Trunked Radio System shall be provisioned for a minimum 2 days of absence of utility AC power without service interruption. UPS systems must be monitored and have alarms shown by the central Radio Management System.

7. Automatic Transfer Switches (ATS) for uninterrupted power supply to generator when utility power supply fails.

8. Antenna entrances to the trunked radio equipment facility shall be fully sealed and protected against lightning strikes.

9. Trunked radio coverage shall be made available above and below ground along the BART operating rail alignment and wayside facilities including the stations, their egress and emergency egress routes, yards and shops, Operations Control Center, maintenance facilities, police zone facilities, administrative offices, revenue processing facilities, and BART park and ride locations.

10. The system shall be designed and have assigned talk-groups for use by BART operations, maintenance, administration, engineering and police personnel.

11. The P25 system shall have Inter RF Subsystem Interface (ISSI) connections and specific talk-groups for inter-agency operations including fire, police, and other emergency agency personnel throughout the Bay Area along BART’s right of way.

B. Modification and Additions

Modifications or additions to the system shall follow the design criteria:

1. Modifications, extensions, or upgrades to the Trunked Radio System design shall be fully compatible with and become an integral part of the existing radio network. The design approach shall show a complete installation process, maintaining an un-interrupted and fully functional radio operational system throughout the modification and addition duration.

2. The products shall utilize the Enhanced Digital Access Communication System (EDACS) format, as manufactured by MACOM, Inc. or future replacement technologies fully compliant with P25 systems.

3. Unless otherwise specified in the Contract, the Trunked Radio System shall be designed to operate as a GPS-coordinated simulcast system. It shall operate in the 800 Mhz radio band, and contain the 10 duplex 800 Mhz NPSPAC radio channels licensed by FCC and assigned to the District.
4. Trunked Radio System additions shall be next generation replacements or compatible with and provide, at a minimum, the same functions and operability as the existing trunked radio system. This shall include a remote network management capability, and interface to other BART and other agencies’ radio systems. During upgrades to the existing BART EDACS system equipment, to establish compatibility to the new equipment, those upgrades shall become part of the Work, and during the Work the Trunked Radio System shall be fully operational and integrated between new and old elements.

5. An RF coverage assessment to evaluate the feasibility of the proposed extension to existing Trunked Radio System coverage shall be performed as part of the design planning exercise.

   a. Assessment shall consist of two parts:

      1) The first part is a computer-generated mapping showing predicted radio performance from each proposed radio site, as well as a composite model of all sites.

      2) The second part is a drive test to verify real world performance of the computer modeling predictions. Signal strength, urban clutter, and simulcast time domain interference over the BART right of way are minimally required in the computer prediction.

      3) An assessment of RF redundant coverage shall be modelled and plotted in mapping software.

6. Existing system coverage modifications, if required, shall be developed and shown in the predictive mapping of extension sites.

7. A performance guarantee from the manufacturer/designer shall accompany the RF coverage assessment, and if coverage performance is not met, then the designer/manufacturer will be responsible for achieving the required coverage area and performance as a part of current contracts.

8. Though primarily an above ground system, the Designer shall include the equipment and designs necessary to furnish the trunked radio signals into the existing BART underground and trenches by interface to the Fiber DAS or BDA systems and specified buildings by either adequate trunked RF signals, by enhancement by DAS equipment, or by addition of Bi-Directional Amplifier (BDA) equipment to meet specified performance levels.

2.02 SYSTEM INTERFACE REQUIREMENTS

   A. Audio, data, and control signals to and from each newly proposed shall interface with the existing EDACS control point radio equipment at Lake Merritt and future redundant P25 Radio Core(s) locations, which shall also be configured to be compatible with the requirements of the BARTnet, UON, IP and MPL Networks.

   B. Below ground redundant radio coverage shall be provided to subway stations, trenches and tunnel areas, and shall be designed to interface with the radio network equipment in a manner similar to that of the existing below ground radio communication equipment throughout the District. Typically, fiber optic cables are
used to transfer the RF signal between tunnel section equipment and specific above ground radio site equipment. An interface to the underground equipment at the trunk radio site shall be provided in system design. The District uses a Commscope (formerly Andrews) Fiber DAS and Andrew Integrated Management Operation System (AIMOS), Network Management System, and new installations shall be fully compatible with these existing systems, integrating to Commscope (formerly Andrews) monitoring system.

2.03 RADIO SYSTEMS LOCATION

A. Newly proposed transmit sites shall be located to obtain the specified system radio coverage and reliability percentages required. New transmit site facilities shall be protected from existing sources of signal interference to prevent degradation to the Trunked Radio System.

B. New trunked radio site locations shall be placed upon District-owned property or projected-District-owned property along the right-of-way if possible. If the location of District property is not suitable for establishing radio coverage performance, then the Designer shall attempt to find space in an existing and developed radio facility. Failing that, other off-site property locations may be evaluated.

C. Radio Shelter: The Trunked Radio equipment radio system shall be installed in an environmentally controlled communication shelter.

1. The shelter shall be provided with a concrete exterior; AC and UPS power distribution; generator; smoke, heat and power fail detection; interior lighting; a halo ground system; and a bullet-proof door.

2. The shelter shall be as specified herein and in the Contract.

2.04 DISPATCHER CONSOLE EQUIPMENT AND CONTROL POINT RADIOS

Personal computer (PC) based trunk radio dispatch console system and control point radios shall be provided in Operations Control Center, police dispatch centers, and in yard control towers. The system shall be a Designated Matching Product to the radio system, C3 Maestro console system or later compatible evolutions, as manufactured by MACOM Inc./Harris Corp, or units with Console Subsystem Interface (CSSI) integration capabilities for current radio systems. The system shall interface and integrate to the existing EDACS control point and P25 VIDA Core control point or future installed radio equipment at Lake Merritt. Control point radios shall be connected to proper antenna arrays and designed to receive strong over the air radio systems signals and perform to DAQ 5.0 levels.
PART 3 – EXECUTION

3.01 INSTALLATION
A. The radio system elements and backup electric power housing shall be located adjacently. The shelter or equipment room where the radio equipment is mounted shall have access to the building halo or electrical ground system and shall have an efficient HVAC system, generator, and battery UPS system.

B. Installation work shall be completed to the site-specific drawings, weather-proofing and grounding details, and Contract Documents.

3.02 SYSTEM OPTIMIZATION
A. Each base station shall be optimized for coverage and performance. It shall then be integrated into the full BART Radio Network System, without any deterioration of service throughout any part of the BART Radio Network System.

3.03 FIELD TESTING
A. Work shall be performed to complete the testing set out in the test planning Submittals, Contract Drawings, and Contract Specifications.

B. Field testing shall verify that the radio systems equipment has been installed in accordance with the Contract and the system performance criteria. Include inspection, test and measurements of the DC power, turn on and burn in, ground tests, RF components and RF passive system sweep tests, drive test results, the GSI coverage maps for Received Signal Strength Indication (RSSI), uplink power levels, radio voice quality, and BER DBER testing. Test measurements shall be structured and provide a grid and tile granularity for the recorded data.

C. As-built diagrams showing equipment placement and routing for antennas, coaxial cables, AC power, system and network design drawings shall be provided to the District prior to acceptance testing. An RF compliance certificate shall be submitted for each radio system and the systems as a whole at the conclusion of the acceptance testing.

3.04 TRAINING, MANUALS, SPARES, AND SUPPORT
A. Operating manuals, electronic documents including native file formats, and system(s) configurations and back-ups shall be provided, at each equipment location. Copies shall be provided to BART Engineering and Maintenance.

B. Training shall be conducted by the Original Equipment Manufacturer (OEM) or OEM partner engineering staff at District premises for District staff. Sufficient quantity shall be provided to allow staff from all shifts to complete training, in small class sizes.
C. Spares shall be available for the systems for at least 15 years from purchase, and if any components become unavailable, then OEM or OEM partners shall redesign replacements at no cost to the District, to keep equipment fully functional for its life-span.

D. OEM or OEM partners shall provide 24 hours a day, 365 day support with knowledgeable Tier 1 through 4 support staff available to support the systems for 15 years after Acceptance.

E. OEM or OEM partner shall provide recommended preventative maintenance schedules and spares for all equipment.

END OF SECTION 33 83 01